DOCUMENT RESUME

ED 233 876 SE 041 710

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TITLE Mathematics and Global Perspectives: A Working Team.
INSTITUTION Global Perspectives in Education, Inc., New York, N.Y.
PUB DATE Nov 80
NOTE 5p.; Portions may not reproduce well due to marginal legibility.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052) -- Journal Articles (080)
JOURNAL CIT Information Exchange Network Clearinghouse Memo; n18 p3-6 Nov 1980

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Global Approach; *Interdisciplinary Approach; Problem Sets; Resource Units; Secondary Education; *Secondary School Mathematics; Social Studies
IDENTIFIERS PF Project

ABSTRACT

Ways in which mathematics and global education can be combined are described. Following a discussion of the need for having a citizenry capable of analyzing global issues, methods of infusing global education into the mathematics curriculum and math into the social studies curriculum are offered. Half of the document consists of eight sample problems which combine math skills and global issues. The problems (which can be used in either math or social studies classes) address waste in affluent nations, the arms race, population, global income inequalities, and global hunger. A list of resources is included. (DC)

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Mathematics and Global Perspectives: A Working Team

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by Richard H. Schwartz

It is 10:30 AM and an 8th grade social studies class is in progress. A large globe, surrounded by students, is placed conspicuously in the center of the classroom. The students are studying the globe; calculators in hand.

What are the calculators doing in a social studies class? Students are applying math skills to compute the costs in 1850, 1900, 1950, and 1980 of transporting 100 tons of grain 1,000 miles in Canada, Afghanistan, India, Russia, and Argentina. Let's see, Afghanistan in 1850 . . . no trains and no trucks. How many camels would it take to carry 100 tons of grain? The students are examining international and global transportation patterns as an introduction to a unit on the history of transportation technology. But first, they have to know some basics about ratios.

Mathematics for Citizen Competence

The study of mathematics is no longer confined to traditional math courses. The advent of the computer and the new types of information it generates has created the general need for a more sophisticated level of mathematical competence. According to Edward Fiske of *The New York Times*, society's increased capacity to collect and analyze data has triggered "a rethinking at all levels of American education of the kind of mathematical training necessary for people to function as informed and productive citizens." (1/29/80)

A democracy demands a citizenry capable of informing itself about the major issues of the day. The skills and knowledge American citizens need to function effectively have changed as our world has grown more interdependent. Acquiring information about an immediate problem or issue is only the first step in becoming an informed citizen. Citizenship further requires the capacity to analyze the local, national, and global implications imbedded in our personal, local, and national policies. Familiarity with fundamental quantitative concepts and mastery of basic math skills are important elements in understanding both the issues and their implications. Learning to consider relationships among facts and figures and to get numerical values for these relationships is no easy—or unimportant—matter. To critique vague generalizations about the state of the economy, of the population crisis, or the global arms race, one has to know how to ask for and read facts in a way that highlights their significant relationships. Correspondingly, to extrapolate the broader issues and global trends from the wealth of data that lies scattered throughout newspapers, for example, one has to learn to apply the right questions and themes. Mathematics skills and a global perspective can be an exciting team in the effort to educate students to understand and respond effectively to global issues.

In the Math Curriculum

Global perspectives can be infused into math curricula in a number of ways. Rather than comparing the price of apples and oranges, why not develop units which illustrate particular math concepts through problems which simultaneously teach students about world problems and trends. For example, a unit on percentages or fractions can be designed using the relationship between variables such as population, hunger, pollution, energy, waste, and the arms race for sample problems. Another possibility is to focus on one particular global issue (energy, the arms race, hunger) as a theme for teaching a variety of mathematical skills. Both approaches are flexible and can be adapted to the needs of specific classroom and curricular situations. These real world applications have the advantage of being excellent motivators, even for the math agnostics.

In the Social Studies Curriculum

Math problems can also be used to enrich social studies courses. Graphs, percentages, and diagrams often describe our world more clearly than mere numbers or text. Abstract numerical relationships become vivid when visualized in new ways. Using math in social studies will also help students to see that the skills they learn in school have wide and diverse applications. They will better understand the inherent interdependence of the learning process as well as the interdependence of our global society. The real world is full of complex interconnections which are often difficult to see. Students who have acquired an integrated approach to their studies will have a broader, more complete understanding of their world.

Mathematics With a Global Perspective

The following topical divisions illustrate how global issues can be used as themes for teaching math skills at the precollegiate level. The sample problems are also useful when integrated into the study of global issues in social studies courses. Adapted to meet specific curricular needs, they will generate invaluable discussion on themes such as interdependence, change, and conflict.

Most of the sample problems are taken from *Mathematics and Global Survival*, a text which I developed and tested in a college math program at the College of Staten Island.

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Waste in Affluent Nations

PROBLEM 1: It has been estimated that the average American has 50 times the impact on the environment (in terms of resource consumption and pollution) as does a person in a less developed country. How many people in these countries have the same impact as 222.5 million Americans (1980 U.S. population)?

Mathematical Skills: Ratios, large number comprehension, word problems.

Solution: $\frac{50 \text{ Indians}}{1 \text{ American}} \cdot 222.5 \text{ million Americans}$

$= 11.1 \text{ billion Indians}$

Relevant Global Issues: This problem helps students understand that global problems are not primarily a result of rapid population growth but that consumption and waste in affluent countries plays a large role.

Reference: *Pollution: Problems, Projects, and Mathematical Exercises*, Wisconsin Dept. of Public Instruction, p. 50.

PROBLEM 2: From 1946 to 1968 consumption of plastics per person increased 1,024%. For every pound of plastics used in 1946, how many were used in 1968? Repeat for synthetic fibers (1,792% increase), nitrogen fertilizer (534% increase), synthetic organic chemicals (495% increase), and aluminum (317% increase).

Mathematical Skills: Percentages, working with a variable, word problems.

Solution: Let X = number of pounds used in 1968 for every pound in 1946. Increase is

$\frac{X-1}{1} \cdot 100\% = 1,024\% \qquad X-1 = 10.24 \quad X = 11.24$

Relevant Global Issues: This problem illustrates an important reason behind the recent ecological and energy problems: the tremendous changes in materials and technologies used since the end of World War II.

Reference: *Replenish the Earth*, G. Tyler Miller, Jr., Belmont, Calif.: Wadsworth Publishing Co., Inc., 1972, p. 12.

The Arms Race

PROBLEM 3: The combined annual budgets of the UN World Health Organization and the Food and Agricultural Organization would fund the U.S. Department of Defense for about 16 hours. About how many times per year does the U.S. Department of Defense spend the amount of money in these two UN budgets?

Mathematical Skills: Ratios, working with units, word problems.

Solution: $\frac{\frac{365 \text{ days}}{\text{year}} \cdot \frac{24 \text{ hours}}{\text{day}}}{16 \text{ hours/time}} = 548 \text{ times/year}$

Relevant Global Issues: This problem can lead to a discussion of human rights. Compare the monies spent for peace, development, and hunger, with the monies spent for arms! While 10 to 20 million people die annually due to hunger and its effects, the world spent about $425 billion for the military in 1979.

Reference: *Bread for the World*, Arthur Simon, New York: Paulist Press, 1975, p. 123.

PROBLEM 4: In 1973 the Pakistani government allocated $405 million for defense from a total national budget of $608 million. What percent of the budget did the Pakistani government allocate for defense?

Mathematical Skills: Percentages, word problems.

Solution: $\frac{\$405 \text{ million}}{\$608 \text{ million}} \cdot 100 = 66.7\%$

Relevant Global Issues: The answer, 66.7%, illustrates the comparatively larger proportion of national budgets spent on arms by less developed countries, where problems of health, housing, education, and employment are often critical.

Reference: *Ibid.*, p. 128.

Population

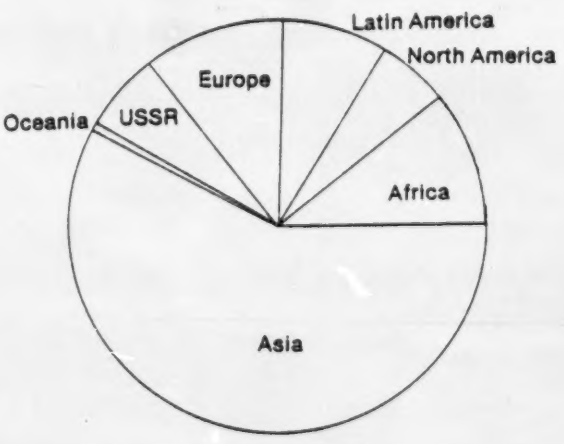
The annual World Population Data Sheet of the Population Reference Bureau, Inc. has much valuable information which can be used for a wide variety of population related problems. Bar charts and histograms lend themselves to the data on death and birth rates, physical quality of life indices, and projected population estimates. More sophisticated problems can involve investigating correlations between such variables as birth rates, life expectancy, and per capita GNP. Portions of the 1980 Data Sheet are reprinted here and used in the following three problems.

PROBLEM 5: Draw a circle diagram showing the population for the major regions of the world. Calculate the percentage of world population for each region.

Mathematical Skills: Percentages, circle diagrams, data analysis, ratios.

Solution:

Africa	(472/4,414) x 100 = 10.7% of 360 = 38.5°
Asia	(2,563/4,414) x 100 = 58.1% of 360 = 209.1°
No. America	(247/4,414) x 100 = 5.6% of 360 = 20.1°
Latin America	(360/4,414) x 100 = 8.2% of 360 = 29.4°
Europe	(484/4,414) x 100 = 10.1% of 360 = 39.5°
USSR	(266/4,414) x 100 = 6% of 360 = 21.7°
Oceania	(23/4,414) x 100 = .5% of 360 = 1.9°
	Total 360.1°



Pie Chart by Mark Zipoli

Relevant Global Issues: A quick glance at the diagram shows clearly the world population distribution among major world regions. Note for example that over half the world's population lives in Asia. Only 5.6% of the world's population lives in North America, yet the U.S. alone uses approximately 35% of the world's resources and energy. These statistics reinforce the idea that disproportionate consumption in the developed countries is a factor in global problems such as pollution, resource scarcity, and hunger.

Reference: "World Population Data Sheet," Population Reference Bureau, Inc., 1337 Conn. Ave., NW, Washington, DC 20036.

PROBLEM 6: At current growth rates, it will take 22 years for Mexico's population to double. At this rate, how many people would there be in Mexico in 110 years, for every one there today?

Mathematical Skills: Sequences, word problems.

Solution: $\frac{110}{22} = 5$ doublings in 110 years

$2^5 = 32$

Relevant Global Issues: The result, 32, dramatically shows the rapid population growth being experienced by Mexico and other less developed countries, and the need for effective steps to reduce that growth. What effects might this rapid growth have on housing, jobs, sanitation, and food by the year 2090?

Reference: *Ibid.*

Global Income Inequalities

PROBLEM 7: Compare the per capita Gross National Product of the United States and El Salvador. For every $1 of El Salvador's per capita GNP how many dollars worth of goods and services does the U.S. produce per individual? Show the same comparison for the U.S. and Nicaragua.

Mathematical Skills: Ratios, selecting appropriate data, word problems.

Solution: $\frac{\text{U.S. GNP/per capita}}{\text{El Salvador GNP/per capita}}$

$= \frac{9700}{600} = \frac{16 \text{ dollars U.S. GNP/pc}}{1 \text{ dollar El Salvador GNP/pc}}$

Relevant Global Issues: This ratio gives students an idea of the comparative comfort and luxury we have in the U.S. What are the consequences of poverty? What relationship does GNP bear to political stability? Have students discuss the civil unrest in El Salvador and the recent revolution in Nicaragua, using the data for these two countries from the Population Data Sheet. For example, consider that 12% of the children born in Nicaragua in 1980 did not live to reach their first birthday. Forty-eight percent of the population is under 15 years of age; population doubling time is 20 years; and life expectancy is 55 years. How do these factors relate to political strife in Nicaragua?

Reference: *Ibid.*

Global Hunger

These problems are most effective when introduced by a few startling facts about world hunger. For example, 1/3 to 1/2 of the world's population is malnourished. Every year 10-20 million people die of hunger or related effects. It is estimated that an average of 274 children per day go blind because of Vitamin A deficient diets.

PROBLEM 8: a) About 4/5 of all grain produced in the U.S. is fed to animals. What percentage does this represent? b) The average diet in the U.S. requires about 3.5 acres per person. The diet of an average person in the less developed world regions requires about 1/5 of an acre. What is the ratio of acres required by a person in the U.S. compared to acres required by a person in a less developed country?

Mathematical Skills: Fractions, ratios, percentages, word problems.

World Population Data Sheet—(excerpts)

Region or Country	Population Estimate Mid-1980 (millions)	Birth Rate	Death Rate	Rate of Natural Increase (annual %)	Number of Years to Double Population	Population Projected for 2000 (millions)	Infant Mortality Rate	Total Fertility Rate	Population under Age 15 (%)	Population over Age 64 (%)	Life Expectancy at Birth (years)	Urban Population (%)	Projected Ultimate Population Size (millions)	Per Capita Gross National Product ($US)
WORLD	4,414	28	11	1.7	41	6,156	97	3.8	35	6	61	39	9,832	2,040
MORE DEVELOPED*	1,131	16	9	0.6	111	1,272	20	2.0	24	11	72	69	1,372	6,260
LESS DEVELOPED*	3,283	32	12	2.0	34	4,884	110	4.4	39	4	57	29	8,460	560
AFRICA	472	46	17	2.9	24	832	140	6.4	45	3	49	26	2,051	530
ASIA	2,563	28	11	1.8	39	3,578	103	3.9	37	4	58	27	5,573	760
NORTH AMERICA	247	16	8	0.7	98	289	13	1.8	23	11	73	74	296	9,650
LATIN AMERICA	360	34	8	2.6	26	595	85	4.5	42	4	64	61	955	1,380
EUROPE	484	14	10	0.4	176	521	19	2.0	24	12	72	69	560	5,650
USSR	266	18	10	0.8	82	311	31	2.4	24	10	70	62	360	3,700
OCEANIA	23	20	9	1.1	61	30	42	2.8	31	8	69	71	37	6,020
United States	222.5	16	9	0.7	99	260.4	13	1.8	22	11	73	74	265.5	9,700
Mexico	68.2	37	6	3.1	22	128.9	70	5.2	46	3	65	65	203.5	1,290
Nicaragua	2.6	47	12	3.4	20	4.8	122	6.6	48	3	55	49	9.3	840
El Salvador	4.8	40	7	3.3	21	8.6	51	6.0	46	3	62	39	13.7	600

1980 World Population Data Sheet, Population Reference Bureau, Inc., Washington, D.C., 1980. Reprinted with permission.

*Classification of "more developed" and "less developed" regions follows the latest (1979) practice of the UN.

Solution: $4/5 \times 100 = 80\%$ and $\frac{3.5}{1/5} = \frac{3.5}{.2} = \frac{17.5}{1}$

Relevant Global Issues: The above two problems can stimulate discussion on distribution systems and food/hunger issues. The solution indicates a meat intensive American diet. While nearly half the world is malnourished, Americans are feeding 4/5 of their grain supply to animals. Problems of hunger can be seen not only as complications of population growth but also of the developed countries' comparatively extravagant appetites. In 1980 there is only one arable acre per person in the world. What accounts for America's disproportionate use of arable land?

Reference: "World Hunger Facts," American Friends Service Committee, 15 Rutherford Pl., New York City, 10003; "To Deal Thy Bread to the Hungry," New York: Union of American Hebrew Congregations, 1975, p. 3; *United Nations Children's Fund* pamphlet.

Conclusion

Students learn interesting and valuable information from math problems which use globally oriented data. More important than the specific information, however, is the process of inquiry they acquire from discussion of the problems and issues involved. In effect, calculating the answer to one of the sample math problems raises a host of other related questions. "How serious is the 'population explosion?' " "Are we running out of natural resources?" "What are the global consequences of U.S. wastefulness?" "What impact has the arms race had on the meeting of human needs?" Themes of interdependence, change, communication, and conflict can be used as organizing themes for discussion of such questions. These themes provide the student with a context for information gathering and further inquiry.

For the past five years, I have taught a college math course which uses critical global issues as themes for learning math skills from basic computations and percentages to introductory statistics. The course has been very successful in heightening students' awareness of global issues. In addition to learning the content of traditional math courses, students learn about global interdependence and the dynamics of change. This knowledge helps them in being able to understand the global implications of events and decisions at the personal, local, and national levels. As a consequence, many students actually changed their personal habits. Several smokers gave up cigarettes, habitual drivers started using more public transportation, and many developed new consumption attitudes and patterns. The students also observed that global problems and alternative solutions more frequently became a topic in their daily conversations with friends and family.

This favorable student response reaffirms my belief that the cross-fertilization of mathematics and global education can improve both fields while greatly increasing students' global awareness. Mathematicians, social scientists, students . . . we are all in this world together. Let's help prepare our students for that global reality.

Dr. Richard Schwartz is associate professor of mathematics at the College of Staten Island where he has pioneered in the field of mathematics and global education. He is the author of *Mathematics and Global Survival*, which can be obtained for $10 by contacting the author at The College of Staten Island, 715 Ocean Terrace, Room H-7, Staten Island, NY 10301.

Resources

The Population Reference Bureau, Inc., 1337 Connecticut Ave., NW, Washington, DC 20036, has many excellent resources in addition to the Data Sheet. Their "Population Handbook" has a summary of demographic techniques and sample problems related to the Data Sheets. They also publish useful teaching modules and bulletins.

The Limits to Growth by D. Meadows, *et al.*, New York: Signet, 1972. While somewhat dated and controversial, this book gives students valuable practice at interpreting material with both mathematical and global applications.

An Introduction to Population, Environment, Society—A Teacher's Resource Manual, by L. Schaefer, 1972. Environment Population Education Services, 21 Merritt St., Hamden, CT 06511. Much valuable information on population growth mathematics. Reprints of articles and questions which can be valuable for background discussions and students reports are included.

World Military and Social Expenditures, 1979, by Ruth L. Sivard, WMSE Publications, Box 1003, Leesburg, VA 22075. An excellent annual publication with information on arms expenditures and the impact on social issues. Charts, tables, and graphs.

The United States and World Development, Agenda, 1979, by Martin M. McLaughlin and the staff of the Overseas Development Council, New York: Praeger, 1979. Lots of tables, charts, and graphs relating information on developmental issues such as trade, the arms race, population growth, education, and health.

Teaching Interdependence: Exploring Global Challenges Through Data, *Intercom* #78, by W. Nesbitt and A. Karls, Global Perspectives in Education, Inc., 218 E. 18th St., New York, NY 10003.

The Mathematics of the Energy Crises, R. Gagliardi, Westmont, N.J.: Intergalactic Publishing Co., 1977. Energy/mathematical problems for secondary students.

Mathematics in Energy, National Science Teachers Association (John M. Fowler, Project Director), Nov. 1978 (Can be obtained from the U.S. Dept. of Energy, Technical Information Center, PO Box 62, Oak Ridge, TN 37830) Energy problems and activities involving mathematics. Also a summary of energy facts.

Energy-Environment Source Book, John M. Fowler, National Science Teachers Association, 1742 Connecticut Ave., NW, Washington, DC 20009, 1975. Comprehensive discussion of energy extraction, conversion, and use, and related environmental problems.

Mathematics for Ecologists, I. Chaston, London: Butterworth & Co., 1971. An introduction to basic principles of advanced mathematics (calculus and linear algebra) applied to ecological problems.

Strategy for Survival: An Exploration of the Limits to Further Population and Industrial Growth, Arthur S. Boughey, Menlo Park, Calif.: W.A. Benjamin, Inc., 1976. A detailed analysis of *The Limits to Growth* (q.v.), and other systems, simulation models, and their implications as to possible limits to growth.

World Facts and Trends, John McHale, New York: Macmillan, 1972.

Pollution Problems, Projects and Mathematical Exercises, Bulletin 1082, Wisconsin Dept. of Public Instruction, Madison, Wisconsin. A wide variety of mathematical problems on environmental issues. Problems are designed for students in grades 6-9; however, they are all word problems, which can be adapted for other levels. (problem 1, p. 50)

The Complete Ecology Factbook, by J. Deedy and P. Nobile, eds., Garden City, N.Y.: Doubleday, 1972. Much ecological data, graphs, and charts; excellent background materials for the construction of mathematical problems.

Population Education Activities for the Classroom, selected and edited by Judith M. Schultz and Herbert L. Coon, ERIC/Center for Science, Mathematics and Environmental Education, The Ohio State University, 1200 Chambers Road, Columbus, Ohio 43212. A wide variety of mathematical and other types of problems related to population, for elementary school level up to senior high school level.